

## TITLE OF THE INVENTION

### Refrigerant Pump and Cooling Device Employing Same

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

5 The present invention relates to a cooling device for cooling, for example, a semiconductor element or elements or the like, which generate a substantial quantity of heat, by utilization of a change in phase between a liquid phase and a vapor phase of a refrigerant. The present invention also relates to an oilfree refrigerant pump employed in such a cooling device.

### 10 2. Description of the Related Art

Fig. 1 depicts a conventional refrigerant pump as disclosed in Japanese Laid-Open Patent Publication (examined) No. 7-47957. The refrigerant pump shown therein includes a pump mechanism 31 and an electric motor 32 for driving the pump mechanism 31. The electric motor 32 includes a stator 33 and a rotor 34 15 rigidly secured to a drive shaft 35 that drives the pump mechanism 31. The stator 33 is positioned in alignment with the rotor 34 in the axial direction of the refrigerant pump.

In the above-described conventional refrigerant pump, because the stator 33 is positioned in alignment with the rotor 34 in the axial direction of the 20 refrigerant pump, which of opposite surfaces of an eccentric portion of the drive shaft 35 receives a thrust force is not determined and, hence, grinding or polishing of both the opposite surfaces of the eccentric portion is required. Furthermore, because the drive shaft 35 is not pushed in only one direction, it sometimes oscillates, giving rise to noises.

25 Fig. 2 depicts another conventional refrigerant pump as disclosed in Japanese Laid-Open Patent Publication (unexamined) No. 3-233188. The refrigerant pump shown therein includes a pump mechanism 41 and an electric motor

42 for driving the pump mechanism 41, wherein a stator 43 is positioned in alignment with a rotor 44 in the axial direction of the refrigerant pump, as in the refrigerant pump of Fig. 1.

The refrigerant pump of Fig. 2 also includes a relatively expensive 5 bushing 45 disposed inside a bearing 46 for rotatably supporting a drive shaft 47.

In the refrigerant pump of Fig. 2, the use of the relatively expensive bushing 45 inside the bearing 46 results in an increase in cost. In the case where a lubricating oil is used to lubricate the bearing 46, there is a good chance that the lubricating oil enters a cooling system employing a cold plate, and adhesion of the 10 lubricating oil to the cold plate lowers the heat transfer performance.

#### SUMMARY OF THE INVENTION

The present invention has been developed to overcome the above-described disadvantages.

It is accordingly an objective of the present invention to provide a 15 reliable refrigerant pump that is low in noise level and can be manufactured at a low cost.

Another objective of the present invention is to provide a high-performance cooling device employing the refrigerant pump referred to above.

In accomplishing the above and other objectives, the refrigerant pump 20 according to the present invention includes a sealed casing, an electric motor having a stator disposed outside the sealed casing and a rotor disposed within the sealed casing, a pump mechanism juxtaposed with the electric motor, and a drive shaft for transmitting a rotational force of the rotor to the pump mechanism, wherein the stator is positioned closer to the pump mechanism than the rotor is.

25 This construction generates, during operation of the refrigerant pump, a thrust force that acts to push the drive shaft towards the pump mechanism so that the drive shaft may be stably held in contact at a surface thereof with a component part

opposed thereto, making it possible to provide a quiet and reliable refrigerant pump. Furthermore, it is sufficient if grinding or polishing is carried out with respect to only the contact surface of the drive shaft with the component part opposed thereto, resulting in a relatively inexpensive refrigerant pump.

5 Advantageously, the surface of the drive shaft is carburized or nitrided, making it possible to provide an oilfree refrigerant pump. A bearing for rotatably supporting the drive shaft may have a carburized or nitrided surface. In the case where the refrigerant pump is free from oil, a reduction in heat transfer performance that has been hitherto caused by oil entering a refrigerating cycle can be avoided, 10 making it possible to provide a high-performance cooling device.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objectives and features of the present invention will become more apparent from the following description of a preferred embodiment thereof with reference to the accompanying drawings, throughout which like parts are 15 designated by like reference numerals, and wherein:

Fig. 1 is a sectional view of a conventional refrigerant pump;

Fig. 2 is a sectional view of another conventional refrigerant pump;

Fig. 3 is a sectional view of a refrigerant pump according to the present invention; and

20 Fig. 4 is a refrigerating cycle of a semiconductor cooling device in which the refrigerant pump of Fig. 3 is employed.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

This application is based on an application No. 2003-164986 filed June 10, 2003 in Japan, the content of which is herein expressly incorporated by reference 25 in its entirety.

Referring now to the drawings, there is shown in Fig. 3 a refrigerant pump embodying the present invention, which includes a sealed casing 1, an electric

motor having a stator 2 and a rotor 4, and a pump mechanism 5 juxtaposed with the electric motor and disposed within and fixed to the sealed casing 2. The stator 2 is disposed outside the sealed casing 1, while the rotor 4 is rigidly secured to a drive shaft 3 disposed within the sealed casing 1. The drive shaft 3 has a large-diameter 5 portion having opposite end surfaces 3a, 3b.

As shown in Fig. 3, the stator 2 is positioned closer to the pump mechanism than the rotor 4 is. More specifically, a central plane 2a of the stator 2 in the axial direction thereof is positioned offset from a central plane 4a of the rotor 4 in the axial direction thereof such that the former is positioned closer to the pump 10 mechanism 5 than the latter by a distance L.

A rotational force of the rotor 4 is transmitted to the pump mechanism 5 via the drive shaft 3. The pump mechanism 5 includes a cylinder bearing 7, a plurality of pump components 8, and a suction plate 6. The cylinder bearing 7 serves both as a bearing for rotatably supporting the drive shaft 3 and a cylinder 15 defining a pump chamber. The surface of the drive shaft 3 is carburized or nitrided, while the inside of the refrigerant pump is free from oil. The surface of the cylinder bearing 7 may be carburized or nitrided in place of the drive shaft 3, or both of them may be carburized or nitrided.

Fig. 4 depicts a refrigerating cycle of a semiconductor cooling device in 20 which an oilfree refrigerant pump referred to above is employed. The semiconductor cooling device shown in Fig. 4 includes a cold plate 21 for cooling a highly exothermic semiconductor element or elements that tend to emit a substantial amount of heat when in operation, a condenser 22, and an oilfree refrigerant pump 23, all connected in series with each other to define a refrigerating cycle. An outlet 25 of the condenser 22 and an inlet of the cold plate 21 are connected with each other with the refrigerant pump 23 interposed therebetween, while an outlet of the cold plate 21 and an inlet of the condenser 22 are connected with each other.

A refrigerant is filled in this refrigerating cycle. The condenser 22 is adapted to be cooled by a fan 24.

The cooling device is so designed that a liquid refrigerant emerging first from the condenser 22 is supplied towards the cold plate 21 by the oilfree refrigerant 5 pump 23. The cold plate 21 so supplied with the liquid refrigerant absorbs heat generated by the highly exothermic semiconductor element and, in the course of absorption of the heat, a change in phase from the liquid refrigerant to a vapor refrigerant takes place within the cold plate 21. The vapor refrigerant is then supplied to the condenser 22 that is then cooled by the fan 24 so that the vapor 10 refrigerant within the condenser 22 undergoes a phase change to a liquid refrigerant.

According to the above-described construction, because the axial central plane 2a of the stator 2 is positioned closer to the pump mechanism 5 than the axial central plane 4a of the rotor 4, when the electric motor is energized, a thrust force as indicated by an arrow A that acts to push the rotor 4 towards the pump 15 mechanism 5 is created, as shown in Fig. 3. This thrust force also acts to push towards the suction plate 6 the drive shaft 3 to which the rotor 4 is rigidly secured so that the end surface 3a of the large-diameter portion of the drive shaft 3 may be stably held in contact with the suction plate 6. On the other hand, the end surface 20 3b of the large-diameter portion of the drive shaft 3 remote from the suction plate 6 is brought into contact with the cylinder bearing 7 under a considerably small pressure or is not brought into contact therewith.

Accordingly, grinding or polishing is required with respect to only the end surface 3a of the large-diameter portion of the drive shaft 3. That is, the end surface 3a remote from the electric motor has a higher precision than the end surface 25 3b, resulting in an inexpensive drive shaft. Furthermore, noises that have been hitherto caused by oscillation of the drive shaft 3 are reduced.

In addition, because the surface of the drive shaft 3 is carburized or

nitrided, and the inside of the refrigerant pump is free from oil, a reduction in the heat transfer coefficient between the refrigerant and an object to be cooled (the cold plate in this case) that has been hitherto caused by oil contamination of the refrigerating cycle can be reduced, making it possible to prevent the cooling power from reducing.

5           Although the present invention has been fully described by way of examples with reference to the accompanying drawings, it is to be noted here that various changes and modifications will be apparent to those skilled in the art. Therefore, unless such changes and modifications otherwise depart from the spirit and scope of the present invention, they should be construed as being included  
10 therein.